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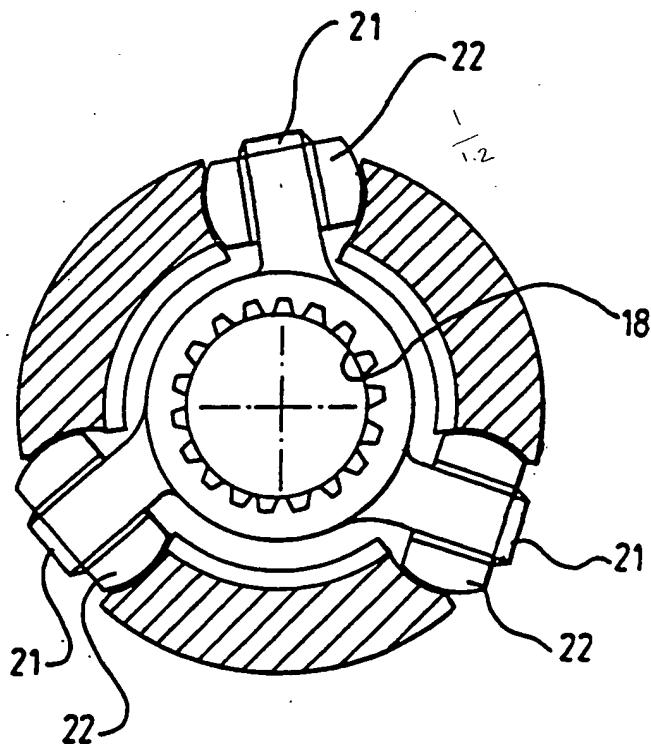
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(54) Title: TRIPODE TYPE CONSTANT VELOCITY RATIO UNIVERSAL JOINTS

(57) Abstract

A tripode type constant velocity ratio universal joint, comprising a first joint member (10) having a rotational axis (12) and three tracks (14) circumferentially spaced about its rotational axis and extending lengthwise of the joint member; a second joint member (11) having a rotational axis and three arms (21) circumferentially spaced about such axis and extending into the tracks of the first joint member; each arm carrying a respective roller (22) having an axis and an external surface which is a surface of revolution about said axis and which engages opposed side portions of the associated track, each roller having its orientation constrained relative to one joint member and being able to move within its associated track such that the first and second joint members are able to undergo articulation relative to one another; wherein, as the joint is viewed axially in cross section, the axis of each roller (22) does not intersect the axis of rotation of the joint member relative to which its orientation is constrained.



## Title: Tripode Type Constant Velocity Ratio Universal Joints

## Description of Invention

This invention relates to constant velocity ratio (homokinetic) universal joints of the tripode type, such a joint comprising a first joint member having a rotational axis and three tracks circumferentially spaced about its rotational axis and extending lengthwise of the joint member; and a second joint member having a rotational axis and three arms circumferentially spaced about such axis and extending into the tracks of the first joint member, each arm carrying a respective roller having an axis and an external surface which is a surface of revolution about said roller axis and which engages opposed side portions of the associated track, each roller having its orientation constrained relative to one joint member and being able to move within its associated track such that the first and second joint members are able to undergo relative articulation, i.e. to enable the rotational axes of the joint members to be inclined to one another. Such a joint will hereafter be referred to as a tripode type joint of the kind specified.

Tripode type joints of the kind specified are widely used in motor vehicle drive lines, for example as the inboard and/or outboard universal joints of drive shafts extending laterally to drivable wheels of a vehicle. A type of joint of the kind specified usually used as the inboard universal joint of a drive shaft provides for the first and second joint members to be able to move axially relative to one another as well as to undergo relative articulation. The relative axial movement ("plunge") in the joint is necessary to accommodate length variations in the drive shaft which occur as a result of vehicle suspension movement. Joints used as the outboard universal joints in drive shafts of front wheel drive vehicles are of a construction which does not enable them to accommodate plunge, but does enable them to articulate to a much greater angle than is possible with plunging inboard joints, in order to accommodate steering of the front wheels of the vehicle.

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In conventional tripode joints of the kind specified as generally used hitherto, the tracks in the first joint member extend parallel to the rotational axis of such joint member, and the arms of the second joint member each extend perpendicular to the rotational axis of the second joint member. More recently it has been proposed that in longitudinal section through a joint the tracks of the first joint member might be inclined to the rotational axis thereof instead of being parallel thereto, whilst the arms of the second joint member are not perpendicular to the rotational axis of the second joint member but inclined to such perpendiculars. The purpose of making the joint of this configuration is to reduce cyclical, predominantly third order, axial forces arising between the joint members due to frictional effects. Such axial forces are one factor in the excitation of drive line vibrations in motor vehicles which can, under certain circumstances, result in undesirable NVH (noise-vibration-harshness) characteristics in the vehicle.

There are, however, other parameters resulting from the construction and geometry of tripode type joints which influence the NVH behaviour of a joint. It is broadly the object of the present invention to provide a tripode type universal joint of the kind specified wherein another of the factors potentially producing undesirable NVH characteristics is altered beneficially.

According to the invention, we provide a tripode type joint of the kind specified wherein, as the joint is viewed axially in cross-section, the axis of each roller does not intersect the rotational axis of the joint member relative to which its orientation is constrained. The result is that the line of action of the force at each roller due to torque transmission between the first joint member and the respective arm of the second joint member is inclined to the tangent at the centre of the respective track to the pitch circle diameter of the tracks.

This provision in a joint according to the invention has the effect of substantially reducing the tertiary moment of the joint, i.e. the reaction moment produced about an axis perpendicular to the plane containing the axes of rotation of the two joint members when the joint is articulated. The tertiary moment produced by a joint may excite drive line vibrations in the direction transverse to

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the joint. In a front wheel drive vehicle, where drive shafts extend laterally from an engine-gearbox-differential unit, this may cause vibration of such unit in the up and down and/or fore and aft direction in susceptible vehicles. The tertiary moment effect is primarily a third order effect, i.e. at three times the speed of rotation of the joint, and therefore for some vehicles reduction of the tertiary moment produced by joints may be very advantageous.

There are different types of tripode joints of the kind specified, differing from one another in respect of the arrangement by which the rollers are supported relative to their respective arms of the second joint member. In one type of joint, each roller is held on its arm of the second joint member so as to be able to rotate thereabout and slide lengthwise of the arm, but is not able to change its overall orientation relative to the arm. The roller axis and arm axis coincide. The roller is able to tilt in its track to accommodate articulation of the joint.

In this type of tripode joint, the disposition of the axis of each roller, according to the invention, may be achieved by inclining each arm, as the joint is viewed axially in cross-section, such that the longitudinal axis of the arm does not pass through the axis of rotation of the second joint member but instead is spaced from such axis.

In another type of tripode joint of the kind specified, each roller is able to change its orientation relative to the respective arm on which it is carried and has its orientation constrained relative to the first joint member. The roller is supported in its track in the first joint member in such a way as to be able to roll along the track but not change its orientation with respect to the track.

In one such type of joint, the arms have part-spherical end portions on which the rollers are respectively carried by intermediate bearing assemblies. In another such type of joint, the arms have cylindrical surfaces on which the rollers are respectively carried by intermediate bearing assemblies, each such bearing

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assembly incorporating cooperating surfaces, e.g. cooperating part-spherical surfaces or a part-spherical surface engaging in an internal cylindrical surface, enabling the rollers to change their orientation relative to the arms on which they are carried.

In these types of joint, disposition of the axis of each roller, according to the invention, may be achieved by inclining each track, as the joint member is viewed axially in cross-section, such that the opposed side portions of the tracks engaged by the rollers are not oriented opposite one another on a line extending tangentially to the pitch circle of the tracks but instead are on a line inclined to such tangents.

By way of example, the rollers may be oriented such that their axes are offset from the axis of rotation of the joint member relative to which their orientation is constrained by approximately  $\frac{1}{8}$  the pitch circle radius of the tracks in the first joint member.

In certain circumstances, it may be desirable to combine the expedients according to the invention as above set forth, in a joint.

Further, the invention may be combined in a joint with the provision of other expedients which have been proposed to be applied to tripode joints to alter other transmission characteristics thereof, for example the orientation of the tracks in the first joint member other than parallel to the rotational axis of the joint member, and/or the orientation of the arms of the second joint member other than perpendicular to the rotational axis of such joint member as the joint is viewed laterally in section, in the case of joints where such arm orientation has an effect on joint characteristics.

The invention will now be described by way of example with reference to the accompanying drawings, of which:-

Figure 1 is a side view, partly in section, of a first embodiment of joint according to the invention;

Figure 2 is an axial view, partly in section of the joint of Figure 1;

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Figures 3A and 3B are axial views, partly in section, of part of a joint respectively as generally known hitherto and as modified in accordance with the invention;

Figures 4A and 4B, and 5A and 5B, are views as Figures 3A and 3B of further types of joint;

Figures 6A and 6B are views as Figures 3A and 3B of yet a further type of joint;

Figures 7 and 8 are views as Figure 1 of further features which may be provided in joints according to the invention.

Referring firstly to Figures 1 and 2 of the drawings, these show a first embodiment of tripode type constant velocity ratio universal joint in accordance with the invention. The joint comprises a first joint member 10 and a second joint member indicated generally at 11, the joint members having respective rotational axes which in the illustrated condition coincide with one another and are indicated at 12, the joint being shown in the aligned (non-articulated) condition. The first joint member 10 comprises a body 13 which is generally of hollow cylindrical form, with three tracks 14 equally circumferentially spaced about its rotational axis 12 and extending parallel to such axis. The body 13 has a closed end 15 from which a stub shaft 16 extends for torque transmitting connection to a rotary component of, for example, a motor vehicle drive line. The second joint member 11 comprises an annular body 17 whose interior is splined for torque transmitting connection to a splined end portion 19 of a drive shaft element 20. Three arms 21 extend outwardly from the body 17 of the second joint member 11, into the tracks 14 of the first joint member 10, and each arm carries a respective roller 22. The arms 21 are oriented as described with reference to Figure 3B. The rollers have external surfaces which engage opposed side portions of the respective tracks in such a manner as to be able to move along the tracks and tilt in the tracks. The external surface of each roller is a surface of revolution about a roller axis and the rollers are supported on their respective arms so as to be rotatable about the roller axes which coincide with the

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longitudinal axes of the arms, and also are movable lengthwise of their respective arms. Thus the two joint members are connected together for torque transmission between them and also to enable them to be relatively articulated, i.e. for the rotational axes of the two joint members to become inclined to one another. The joint is also able to undergo plunge, i.e. relative axial movement between the joint members.

Referring now to Figure 3A of the drawings, this shows, in an axial view partly in cross-section, one arm, roller, and associated track, of a joint as above described, but as generally known hitherto and thus not in accordance with the present invention. In this Figure, the arm extending from the second joint member is indicated at 30 and the roller carried by the arm at 31. A needle roller bearing assembly 32 is interposed between the arm and the interior surface of the roller 31, to enable the above described rotation of the roller about the arm and movement of the roller lengthwise of the arm. The longitudinal axis of the arm about which such movement of the roller occurs is indicated at 33 and in a conventional tripode joint the axis 33 passes through the rotational centre of the joint member whose position is indicated at 34. The external surface of the roller 31 is partspherical in configuration, and opposite side portions 35 of the track in the first joint member are portions of a cylindrical surface the position of whose central axis is indicated at 36. The distance between the position 36 of all the tracks in the joint member and the rotational axis of the joint member which when the joint is aligned is coincident with the point indicated at 34, is the pitch circle radius of the tracks in the joint member.

Figure 3B shows how a joint as shown in Figure 3A is modified in accordance with the present invention. This Figure shows that the longitudinal axis, indicated at 33a, of the arm, and thus the roller axis, is inclined to the radial direction, so that it does not pass through the rotational axis of the joint member but instead is spaced therefrom by a perpendicular distance as indicated at 37. By way of example, the offset 37 of each of the longitudinal axes 33a of the arms

30 from the rotational axis of the joint member may be approximately one-third of the pitch circle radius of the tracks in the other joint member.

Referring now to Figures 4A and 4B of the drawings, these show another embodiment of tripode-type constant velocity ratio universal joint, respectively as generally known hitherto and in accordance with the present invention. Referring firstly to Figure 4A of the drawings, an arm of a second member of a joint is indicated at 30, and the arm has a spherical head 31. A roller assembly carried by the arm comprises a roller 42, a needle roller bearing assembly 43, and an inner roller element 44 which has a cylindrical internal surface so that it is able to pivot universally about the spherical head 31 of the arm 40. The roller 42 has an outer peripheral surface 45 which engages opposed side portions 46 of the track in the first joint member 47. The side portions of the track have abutment surfaces 46a, 44b which engage end faces of the roller, so that although the roller 42 is able to move lengthwise of the track, it is not able to tilt therein, so that when the joint is articulated the roller assembly has to tilt relative to the arm 40, which is possible by virtue of the spherical head 31 of the arm.

In a joint of this type, because of the spherical head portion 41 of each arm 40, the disposition or orientation of the arm is of no consequence. The necessary orientation of the roller axis, and thus of the line of action of the force due to torque transmission between the first joint member and arms of the second joint member is therefore achieved by inclining the track, as the joint member is viewed axially in cross-section, such that the opposed side portions of the track are not oriented tangentially to the pitch circle of the tracks but instead are inclined to such tangent. This condition is illustrated in Figure 4B, where the pitch circle of the tracks (and of the centres of the spherical heads of the arms) is indicated at 48, and the line of orientation of the opposed side portions 46 of the track at 49. The line 49 is inclined to the tangent to the pitch circle 48 at the centre of the track, whilst the line 50 normal to the line 49 is inclined to the radius 51 of the joint member 47. The line 50 is offset from the rotational axis

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as indicated at 52 of the joint member 47, in analogous manner to the offset of the axis of arm 30 from the axis 34 in the joint shown in Figure 3B.

Referring now to Figures 5A and 5B of the drawings, these show a further embodiment of universal joint wherein the necessary tilting movement at each roller assembly when the joint is articulated takes place within the roller assembly rather than between roller and track. Referring firstly to Figure 5A, one of the arms of the second joint member is shown at 53, and on this is carried an inner roller element 54 with the interposition of a needle roller bearing assembly 55. The inner roller element can rotate about the arm but is unable to move lengthwise of the arm. The inner roller element 54 has a part-spherical outer surface 56 and this engages a cylindrical internal surface 57 of roller 58. The external surface of roller 58 engages opposed side portions 59 of the track in the first joint member 60 in such a way that the roller 58 can move lengthwise of the track but not tilt therein. Tilting when the joint is articulated takes place between the inner roller element 54 and roller 58. The pitch circle of the tracks in the joint member 60 is indicated at 61, and the rotational axis of the joint member at 62.

Figure 5B illustrates how a joint of the kind shown in Figure 5A may be modified to be in accordance with the invention. Analogously to the inclination of the track of the joint shown in Figure 4B, the opposed side portions of the track are oriented at an inclination to the tangent to the pitch circle at the centre of the track. Thus the roller 58 is correspondingly oriented such that the roller axis is spaced from the axis of rotation of the first joint member.

Referring now to Figures 6A and 6B of the drawings, these show a further embodiment of joint which has certain similarities to the embodiment of Figures 5A and 5B but differs in respect of the construction of the roller assembly. In Figure 6A, the roller assembly comprises an inner roller element 64 carried on the arm with a needle roller bearing assembly 65 which permits the inner roller element to move lengthwise of the arm as well as rotate thereabout. The inner roller element 64 has a part-spherical outer surface 66 and this engages

a part-spherical internal surface 67 of roller 68. The configuration of the track in the first joint member which engages the roller to maintain the orientation of the roller with respect to the first joint member is the same as shown in the joint shown in Figure 5A.

Figure 6B shows how a joint as shown in Figure 5A can be modified in accordance with the invention. The track is inclined to the tangent to the pitch circle of the tracks, in exactly the same manner as shown in Figure 5B. Thus the axis of the roller 68 is, as the joint is viewed axially in cross-section, spaced from the axis of rotation of the first joint member relative to which the orientation of the roller is constrained.

The above described inclination of the tracks and/or arms of the joint, as the joint is viewed axially in cross-section, may be combined with other features which it has been proposed to provide in tri-pode joints to achieve particular transmission characteristics of such joints. As the joint is viewed longitudinally in cross-section, for example, the tracks may extend at an orientation other than parallel to the rotational axis of the joint member in which they are provided, and/or in joints where the rollers have their orientation constrained relative to the arms the arms may be oriented such that their axes are other than perpendicular to the rotational axis of the joint member having the arms. Such possible additional features of track and/or arm orientation are shown in Figures 7 and 8 of the drawings. They may be as disclosed in our International patent application publication WO 93/22577, or our International patent application GB94/02263.

Figure 7 shows a joint with first and second joint members 70, 71 having respective rotational axes 72, 73. The first joint member 70 has tracks one of which is indicated at 74 which extend parallel to the rotational axis 72. One of the arms of the second joint member 71 is shown at 75, and the longitudinal axis 76 of the arm is inclined to the perpendicular 77 to the rotational axis 73 of the second joint member. Figure 8 shows a joint with a first joint member 80 and second joint member 81, with rotational axes 82, 83 respectively. The tracks, one

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of which is shown at 84, in the first joint member 80 are not parallel to the rotational axis 82 thereof but converge as they extend from the closed to the open end of the joint member. The inclined centre line of the track is indicated at 85. The arms one of which is shown at 86 of the second joint member 81 have their axes as indicated at 87 inclined to the perpendicular 88 to the rotational axis 83 of the second joint member, but in the opposite sense to the inclination of the arms as 75 in the joint shown in Figure 7.

In all the joints described above, the tracks of the first joint member, and hence the arms of the second joint member, are equally circumferentially spaced about the axis of the respective joint member. In some circumstances it may be the case that the arms and correspondingly also the tracks, are not equally spaced. For certain applications, such rotational asymmetry in the joint may produce particularly desired characteristics which, in combination with the present invention, are advantageous.

Further, in a joint according to the invention it may be desired to arrange for the offsets of the three rollers of the joint, from the axis of rotation of the respective joint member, to be different from one another.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

## CLAIMS

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1. A tripode type constant velocity ratio universal joint, comprising a first joint member having a rotational axis and three tracks circumferentially spaced about its rotational axis and extending lengthwise of the joint member; a second joint member having a rotational axis and three arms circumferentially spaced about such axis and extending into the tracks of the first joint member; each arm carrying a respective roller having an axis and an external surface which is a surface of revolution about said axis and which engages opposed side portions of the associated track, each roller having its orientation constrained relative to one joint member and being able to move within its associated track such that the first and second joint members are able to undergo articulation relative to one another; wherein, as the joint is viewed axially in cross-section, the axis of each roller does not intersect the axis of rotation of the joint member relative to which its orientation is constrained.

2. A joint according to Claim 1 wherein the axis of each roller is offset from the axis of rotation of the joint member relative to which it is constrained by approximately  $\frac{1}{3}$  the pitch circle radius of the tracks in the first joint member.
3. A joint according to Claim 1 or Claim 2 wherein each roller is carried on its arm so as to be able to rotate thereabout and slide lengthwise of the arm, but otherwise to remain in a fixed orientation relative to the arm, and wherein each arm is inclined such that the longitudinal axis of the arm is spaced from the axis of rotation of the second joint member.
4. A joint according to Claim 1 or Claim 2 wherein each roller is carried on its respective arm in such a way as to be able to change its orientation relative to the arm, and is supported in its respective track such that its axis does not intersect the axis of rotation of the first joint member.

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5. A joint according to Claim 4 wherein the roller is supported on the respective arm by an inner roller element which is not able to change its orientation relative to the arm, and wherein the longitudinal axis of the arm is spaced from the axis of rotation of the second joint member.

6. A joint according to Claim 3 wherein, as the joint is viewed laterally in cross-section, the tracks in the first joint member are oriented at an inclination other than parallel to the rotational axis of that joint member, and/or the arms of the second joint member are oriented at an inclination other than perpendicular to the rotational axis of that joint member.

7. A joint substantially as hereinbefore described with reference to Figure 2, or Figure 3B, or Figure 4B, or Figure 5B, or Figure 6B, or as modified in accordance with, Figure 7 or Figure 8 of the accompanying drawings.

8. Any novel feature or novel combination of features described herein and/or in the accompanying drawings.

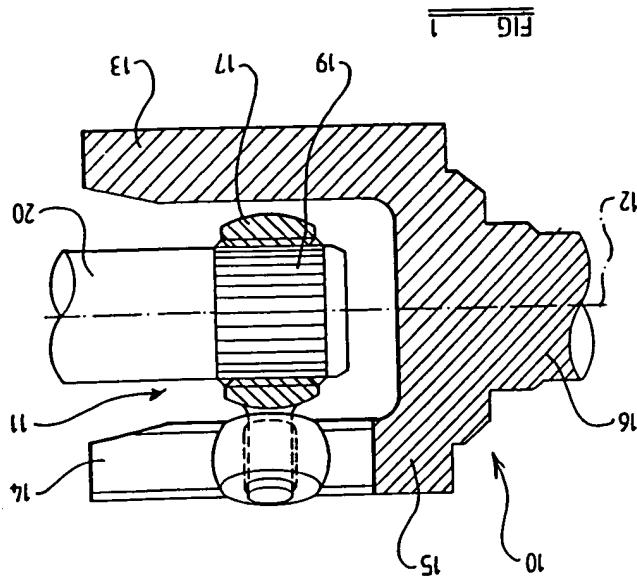
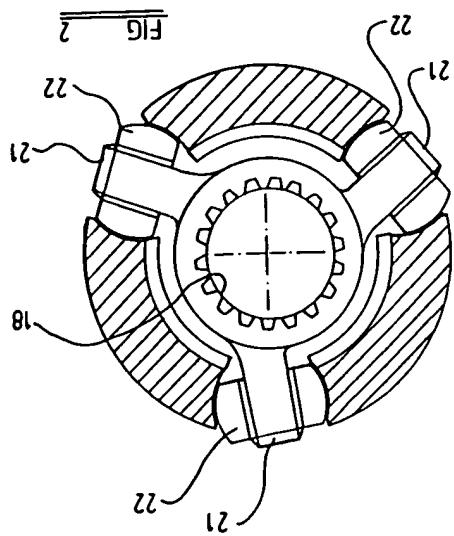
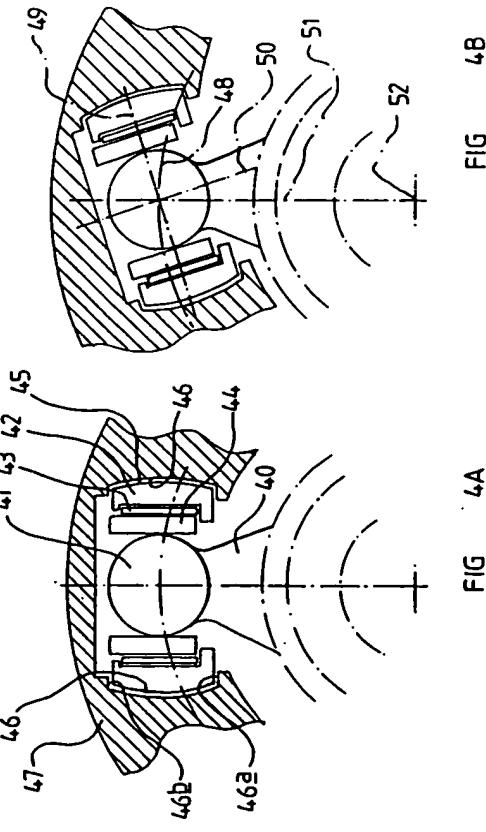
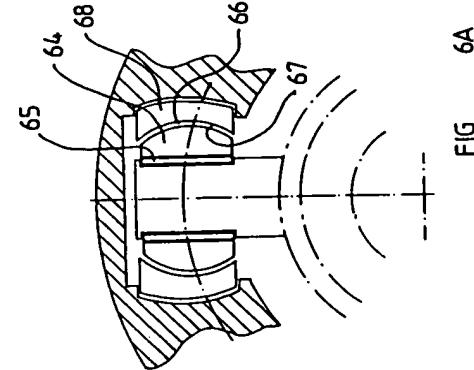
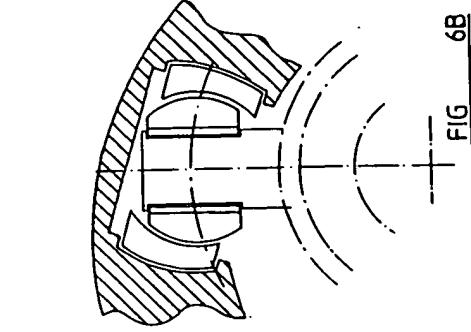
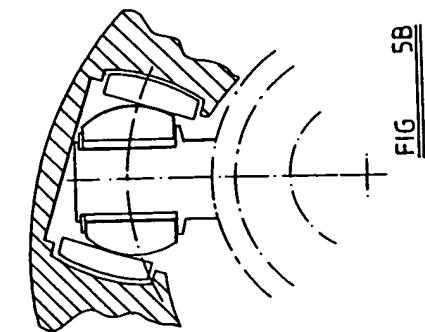
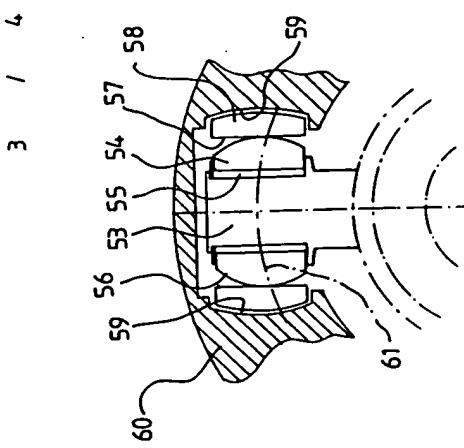
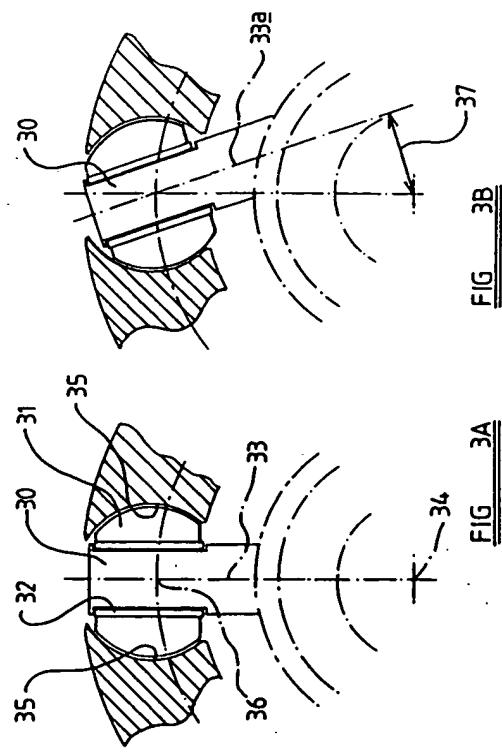
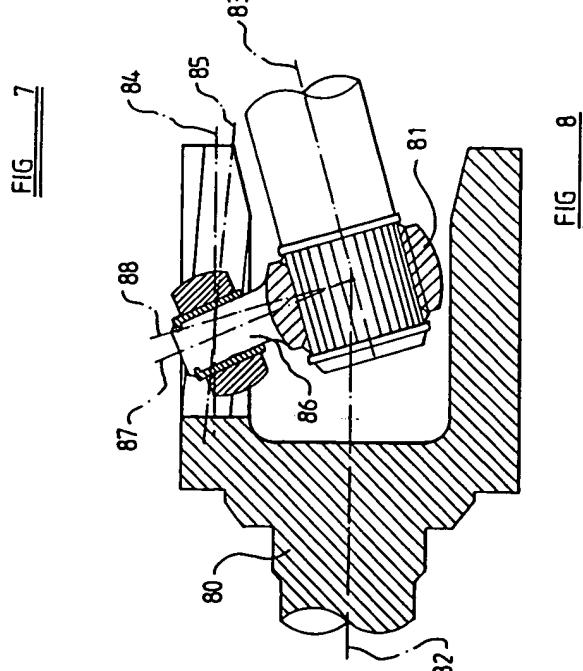
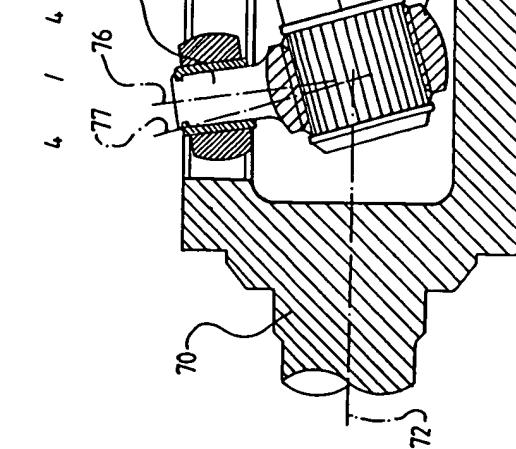


FIG 1

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category	Character of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR,A,2,567,222 (NIPPON) 10 January 1986 see page 11, line 6 - line 19; figures 12,13	1,3,4,7 6
Y	see page 23, line 1 - line 27; figure 35 --- EP,A,0,453,334 (GLAENZER SPICER) 23 October 1991 see column 3, line 9 - column 4, line 40; figures 1-3	6
A	US,A,4,472,157 (SINDELAR) 18 September 1984 see figures 18,20 --- GB,A,2,161,246 (UNI-CARDAN) 8 January 1986 see figure 3 ---	1,3 1,4
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